

FORMS

a. General. - Forms shall be used, wherever necessary, to confine the concrete and shape it to the required lines. The Contractor shall set and maintain concrete forms to ensure that completed work is within all applicable structural deviations, surface tolerances, and finish requirements. If a type of form does not consistently perform in an acceptable manner, the type of form shall be changed and the method of erection shall be modified.

A sufficient number of properly installed plumb and string lines shall be installed before, and maintained during, concrete placement for use by Contractor's personnel and Government inspectors. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.

Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in proper position. The design of formwork and placing rate of concrete containing type F or G chemical admixtures shall be adjusted to compensate for the greater hydraulic pressures exerted on the forms by concrete of high fluidity. ¹(Where form vibrators are to be used, forms shall be sufficiently rigid to effectively transmit energy from the form vibrators to the concrete, while not damaging or altering positions of forms.) Surfaces and joints of forms shall be sealed sufficiently to prevent absorption of water into forms or loss of mortar from the concrete. Chamfer strips shall be placed in the corners of forms and at the tops of wall placements to produce beveled edges on permanently exposed concrete surfaces. Interior angles of intersecting concrete surfaces and edges of construction joints shall not be beveled except where indicated on the drawings.

²(Inside forms for circular siphons, in which the siphon barrels are placed monolithically without longitudinal or horizontal construction joints, shall be constructed to cover only the arch and sides, leaving the bottom 65E, plus or minus 5E, of the inside circumference to be placed without forming.)

³(Inside forms for nearly horizontal circular tunnels having an inside diameter of 12 feet or more shall be constructed to cover only the arch and sidewalls. The bottom 65E, plus or minus 5E, of the inside circumference shall be placed without forming: Provided, That the Contractor may increase the angle of the inside circumference to be placed without forming on written approval of the Contracting Officer. Request for approval shall be accompanied by complete plans and a description of the proposed placing methods.)

⁴[Forms for tunnel lining shall be provided with access openings along each sidewall and in each arch to facilitate concrete placement and consolidation. Each opening shall be not less than 2 by 2 feet and shall be located in the crown and along each sidewall as follows:

- (1) Openings in the crown shall be spaced 8 to 10 feet on centers and shall be located alternately on each side of the tunnel centerline.

(2) Openings in sidewalls of forms for tunnels having an inside diameter less than 12 feet shall be located at midheight of the tunnel and shall be spaced 8 to 10 feet on centers along each sidewall.

(3) Openings in sidewalls of forms for tunnels having an inside diameter of 12 feet or more shall be located along two longitudinal lines in each sidewall, at locations which are approved by the Contracting Officer. The openings along the two selected longitudinal lines in each sidewall shall be staggered and shall be spaced 8 to 10 feet on centers along each longitudinal line. Chord forming of horizontal curves with straight forms is allowable provided:

(4) The length of chord is less than 1.5 times the square root of the radius of the curve.

(5) The chord shall depart from alignment equal and opposite distances at the ends and the center, and shall maintain the minimum specified concrete thickness between the inside surface of all steel support members and the finished surface of the tunnel lining.]

⁵(Forms for concrete surfaces for which finish F3 is specified shall not be constructed continuously from lift to lift, but shall be removed after concrete in a lift has hardened and reset for the next lift. The reset forms shall overlap the hardened concrete in the lift previously placed by not more than 1 inch and shall be tightened snugly against the hardened concrete so that, when concrete placement is resumed, the forms will not spread and allow offsets or loss of mortar at construction joints. Additional bolts or form ties shall be used as necessary to hold the reset forms tight against the hardened concrete.)

b. Form sheathing and lining. - Wood sheathing or lining shall be softwood or plywood of such kind and quality, or shall be so treated or coated, that there will be no deterioration or discoloration of the formed concrete surfaces due to chemical action, contamination, or uneven absorption of water from concrete. Plywood used for form sheathing or lining shall be concrete form, class 1, grade B-B, exterior, mill oiled and edge sealed, in accordance with the latest edition Product Standard PS1 of the U.S. Department of Commerce. Softwood lumber used for form sheathing shall meet applicable requirements of the latest edition of the Grading Rules for Western Lumber as published by the Western Wood Products Association for dressed lumber or worked lumber of the specified grade. All common boards shall be surfaced on both edges (S2E) in accordance with the standard grading rules.

The ability of form sheathing and lining to withstand distortion caused by placement and vibration of concrete shall be such that formed surfaces will conform with specified structural deviations, surface tolerances, and finish requirements.

Materials used for form sheathing or lining shall conform to the requirements of table _____ (Form sheathing or lining material requirements) below, or may be other materials producing equivalent results. ⁵(The basic modular size of sheathing material for finish F3 shall be 4- by 8-feet. The dimensions of filler panels for corners, soffits, and similar offsets, may be smaller, but the panels shall be fabricated from similar materials, and the resultant concrete

surfaces shall have a uniform texture. Voids at joints in the plywood form lining or sheathing for finish F3 shall be filled and finished smooth prior to concrete placement. Where finish F3 is specified, the sheathing or lining shall be in alignment both horizontally and vertically, and shall be placed to minimize joint marks on the concrete surfaces.)

⁶Table __. - Form sheathing or lining material requirements

Required finish of formed surface	Wood sheathing or lining	Steel sheathing or lining
F1	Any grade common board,	Steel sheathing permitted Steel lining permitted
F2	No. 2 common or better, shiplap, or plywood	Steel sheathing permitted Steel lining permitted if approved
F3	Plywood	Steel sheathing permitted Steel lining not permitted
F4	For plane surfaces, plywood shall be used. For warped surfaces, plywood or lumber which is free from knots and other imperfections and which can be cut and bent accurately to the required curvatures without splintering or splitting shall be used. Where required curvature is especially severe, forms may be lined with continuously supported, flexible material such as masonite or thin plywood. Use of such liners and construction and materials shall be subject to approval by the Contracting Officer ⁷ [For warped hydraulic surfaces of ⁷ (draft) (suction) tubes see subparagraph ⁷ (c) (d) below.]	Steel sheathing permitted Steel lining not permitted

* Steel "sheathing" denotes steel sheets not supported by a wood backing. "Lining" denotes thin sheets supported by a wood backing.

⁷(c. Uniformity of forming material. - Forms for exposed concrete surfaces to receive finishes F2 and F3 shall be constructed to produce a uniform and consistent texture and pattern on the face of the concrete. Metal patches on forms for these surfaces will not be permitted. The form sheathing or lining shall be placed so that all horizontal form marks are continuous across the entire surface. If forms are constructed of plywood form lining or of panels of shiplap, the vertical form marks shall be continuous for the entire height of the

surface. If forms for concrete surfaces to receive F2 finishes are constructed of shiplap that is not paneled, the boards shall be cut square, and the vertical joints in the boards shall be staggered and shall be made only at studs. The Contractor shall use one type of form material for all exposed F2 surfaces and one type of form material for all F3 surfaces. If the Contractor elects to use shiplap for forms for F2 surfaces, the lumber shall either be all 6- or all 8-inch wide lumber.)

7[____. Forms for warped hydraulic surfaces. - Forms for concrete to be placed in the 7(draft) (suction) tubes of the 7(powerplant) (pumping plant) shall be constructed so as to conform accurately to the required curvatures of the sections. Dimensions from the centerlines of the 7(draft) (suction) tubes to the concrete surfaces will be given at several sections throughout the lengths of the 7(draft) (suction) tubes. The Contractor shall interpolate intermediate sections as necessary for the type of form construction being used and shall construct the forms so that the curvature will be continuous between sections. Where the use of flexible materials, as described for F4 finishes, cannot meet the requirements for curvature of warped surfaces of 7(draft) (suction) tubes, the form sheathing shall be built up of laminated splines cut to make tight, smooth form surfaces. The forms shall be so constructed that the joint marks on the concrete surfaces shall, in general, follow the line of waterflow. After the forms have been constructed, all surface imperfections shall be corrected, all nails shall be hidden, and any roughness and all angles on the surfaces of the forms caused by matching the form material shall be dressed to the required curvatures prior to concrete placement.]

____. Form ties and form anchors. - Embedded ties for holding forms shall remain embedded and, except where F1 finish is permitted, shall terminate not less than 2 diameters or twice the minimum dimension of the tie, whichever is greater, from the formed surfaces of the concrete.

The ties shall be constructed so that removal of the ends or end fasteners can be accomplished without causing appreciable spalling at the faces of the concrete. Form anchors shall be provided in sufficient number, subject to approval by the Contracting Officer, to ensure that concrete surfaces, after the forms have been stripped, are within applicable tolerances. Form anchors embedded in concrete which are loosened prior to placement of adjoining concrete shall be replaced by other supports firmly embedded in the hardened concrete.

____. Cleaning and oiling of forms. - At the time the concrete is placed in the forms, the surfaces of the forms shall be free from encrustations of mortar, grout, or other foreign material. Before concrete is placed, the surfaces of the forms 7(, except surfaces of rough lumber for surfaces to be plastered,) shall be coated with a form oil that will effectively prevent sticking and will not soften or stain the concrete surfaces, or cause the surfaces to become chalky or dust producing.

____. Removal of forms. - To facilitate satisfactory progress with the specified curing and to allow the earliest practical repair of surface imperfections, forms shall be removed within 24 hours after the concrete has hardened sufficiently to prevent damage by careful form removal,

and specified repair and curing shall commence immediately thereafter. It is the Contractor's responsibility to design and build adequate forms and to leave them in place until the forms can be safely removed. The Contractor shall be liable for damage and injury caused by removing forms before the concrete has gained sufficient strength. ⁷(Forms on upper sloping faces of concrete, such as forms on the watersides of warped transitions, shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed immediately by the specified curing.)

⁷(To avoid excessive stresses in concrete that might result from swelling of forms, wood forms for wall openings shall be loosened as soon as the loosening can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.) ⁷(Forms for conduits, siphons, and tunnel lining shall not be removed until the concrete strength is such that form removal will not result in perceptible cracking, spalling, or breaking of edges or surfaces, or other damage to the concrete.) ⁷[Forms shall not be removed from siphon barrels ⁷(and conduits) until the concrete has attained a minimum of 25 percent of the specified 28day compressive concrete strength as determined by the Government from concrete cylinders field cured adjacent to the structure to simulate the curing conditions.] Forms shall be removed with care so as to avoid injury to the concrete and any concrete so damaged shall be repaired in accordance with paragraph ____ (Repair of Concrete).

____. Cost. - The cost of furnishing all materials and performing all work for constructing forms, including any necessary treatment or coating of forms, shall be included in the applicable prices bid in the schedule for the items of concrete for which the forms are used.

¹Delete if form vibrators are not required as prescribed in Conc. 14, Placing.

²Delete if circular siphons are not involved in the work.

³Delete if circular tunnels having an inside diameter of 12 feet or more are not involved.

⁴Delete if tunnel linings are not involved. If tunnel linings are involved, delete subparagraph (2) or (3), whichever is not applicable.

⁵Delete if finish F3 is not required.

⁶Delete finishes that are not required.

⁷Delete or revise as required by designer.

5-23-88 Revisions: Revised throughout.